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HEARINGON
Research on Environmental and Safety Implications of Nanotechnology:
What are the Federal Agencies Doing?
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Questions for the Record Submitted to Dr. Arden Bement

<u>Questions for the Record from Congressman Brad Sherman</u>

This hearing focuses on the safety impacts of nanotechnology. I have concerns about the implications of nanotechnology that have not yet been adequately addressed and are often incorrectly dismissed as "science fiction."   It is said that computer engineering can be referred to as "dry nanotechnology," that generic engineering can be referred to as "wet nanotechnology," and that the implantation of computer chips and similar devices into a human or other biological organism is "damp nanotechnology." Thus, the term nanotechnology encompasses the most interesting cutting-edge scientific research. It seems the science that will affect our lives in the biggest way is mighty small, in fact nano-small. All three types of nanotechnology could well lead to what I call "engineered intelligence," i.e. the creation of self-aware entities with intellectual capacities for exceeding the brightest human. Computer engineering (dry nanotechnology) is likely to create artificial intelligence exceeding humans within 25-30 years, according to the consensus of experts who testified before our committee on April 9, 2003. The time will come when genetic engineers will be able to create a 1000 pound mammal with two fifty pound brains capable of a perfect score on the LSAT. And perhaps the first entities with superhuman intelligence will be humans with substantial computer chip implants capable of thinking in ways no ordinary human has. In any case, I refer to all three of these nanotechnologies (dry, wet and damp) when I use the term engineered intelligence.

Dr. Bement, in your written testimony you mention the three main categories of what the National Science Foundation (NSF) characterizes as the "societal dimensions" of nanotechnology and you also go on to say that each of these categories is indispensable. My concern falls within the category of "ethical, legal and other social issues." The ethical and societal repercussions of engineered intelligence should be studied.

1. Please describe in detail the projects that are funded by the National Science Foundation, which address the ethical and societal concerns accompanying the development of nanotechnology. Which of these focus on engineered intelligence in general or artificial intelligence in particular? If there are no such projects, what is the NSF's plan to promote studies addressing these concerns?

Reply: The National Science Foundation is investing $4.8 million in FY 2006 and is seeking $5.4 million in the FY 2007 Request to Congress for ethical, legal, and social issues research and education. The NSF is funding several projects addressing ethical and social concerns of nanotechnology including: two major centers devoted to the examination of nanotechnology in

society at the University of California Santa Barbara (UCSB)and Arizona State University (ASU); two nanotechnology in society research groups, one at Harvard/UCLA and the other at the University of South Carolina; two grants for Nanotechnology Interdisciplinary Research Teams (NIRTs) at the University of Minnesota, and Northeastern; several Nanotechnology Exploratory Research (NERs) grants; two Ethics Education in Science and Engineering (EESE) grants that involve ethical issues associated with nanotechnology; and several standard research grants funded through NSF programs. In addition, the National Nanotechnology Infrastructure Network (NNIN) includes activities related to societal and ethical issues, and a number of Nanoscale Science and Engineering Centers (NSECs) include research components on societal and ethical issues. Most of these projects address a range of mid- and long-range ethical and societal issues including personal privacy, security, identity, human enhancement, regulatory capacity, public perceptions and acceptance, and media coverage.

Although none of the above projects specifically addresses the ethical and societal issues of engineered intelligence or artificial intelligence, three projects directly engage ethical issues associated with nanotechnology and human enhancement. The Center for Nanotechnology in Society at ASU has a research focus on human identity, enhancement and biology. The NSEC for Molecular Function at the Nano/Bio Interface at the University of Pennsylvania has an ethics component. A recently awarded standard research grant to scholars at Dartmouth and Western Michigan University will examine ethical issues associated with human enhancement and nanotechnology, particularly those that may be made possible with nanomaterials and nanoelectronics, e.g. nanotechnologically-augmented vision.

2. It is widely recognized that information about the risks of nanotechnology, to be useful, needs to be communicated to the potential users of that information in an effective way. Information that is not the product of an ongoing dialogue with various stakeholders, such as public health officials, theologians, philosophers, representatives of non-profit organizations, the private sector, and the general public, is not likely to be seen as credible by such stakeholders. Dr. Bement, please describe for me the NSF's plan for ensuring an ongoing dialogue with the public about nanotechnology issues so that the results of ethical and societal studies are valuable and usable for stakeholders. Please particularly focus on the ethical and societal research regarding the impacts of nanotechnology's potential creation of engineered intelligence in each of the three forms I have outlined above.

Reply: NSF has activities in formal and informal education for nanotechnology, as well as public surveys and public participation. For nanotechnology education and outreach alone, NSF has allocated $24.5 million in FY 2006 and $28.0 million in the FY 2007 Request to Congress.

We have several projects that specifically address the need to ensure an ongoing dialogue with the public on nanotechnology.
- Nanotechnology: The Convergence of Science and Society (ESI-0452371, Oregon Public Broadcasting, Needham) is producing three one-hour television programs for national broadcast on the social, ethical, legal, and environmental implications of nanotechnology based on the Fred Friendly Seminar format, accompanied by community-based outreach efforts and a web site.

- The Nanoscale Informal Science Education Network (ESI-0532537, Museum of Science, Bell), which is creating exhibits and media to educate the public about nanoscience and technology, includes development and implementation of public forums in science museums designed to engage adults in discussing potential societal impact.
- Other projects, such as Earth & Sky Nanoscale Science and Engineering Radio Shows (ESI-0426417, EarthTalk Inc., Britton) that will increase general public awareness of nanotechnology and its role in our lives.

There are numerous other activities associated with the projects outlined in the answer above that are designed to foster an ongoing and informed dialogue with various stakeholders including the public. For example, Science Cafes, at which nano-scientists talk about their research and afford members of the public an opportunity to raise questions and concerns, are being held on a regular basis at the University of Wisconsin and ASU. The University of South Carolina has organized several Citizens' Schools of Nanotechnology where members of the public read and discuss nanotechnology and related societal issues over a several-week period. The Harvard/UCLA research project is developing a pilot NanoEthicsBank providing an online database of articles, journals, reports, and meeting minutes related to nanotechnology and ethics; the NanoEthicsBank is accessible to the public and other stakeholders. Several projects, including those at ASU, UCSB, and North Carolina State, have public deliberation activities related to nanotechnology and society. Finally public opinion surveys, as well as scientist surveys, associated with various aspects of nanotechnology and society are being conducted as part of a number of these projects. In all these instances, the local media are utilized to inform the public about the activities.

In addition to the activities focusing on public knowledge, understanding and concerns, several workshops on nanotechnology and society issues have been held in conjunction with NSF funded projects. At these, representatives from academia, non-profits, government and industry have participated. For example, Michigan State held a workshop on what nanotechnology can learn from the experiences of biotechnology. A workshop on ethical issues and nanotechnology is being planned and will be held at ASU.

3. Roughly 2 percent of the National Science Foundation's FY2007 request for the National Nanotechnology Initiative goes to "ethical, legal, and social issues", while about 8 percent is directed toward environmental, health and safety research. Dr. Bement, you state in your submitted testimony that "ethical, legal, and social issues" are an important dimension of the study of nanotechnology's societal issues. Then, why is so little of the funding for the National Nanotechnology Initiative (NNI) directed towards the "ethical, legal, and social issues" category?

Reply: The support for "ethical, legal, and social issues" was determined by the need for funding the relevant and meritorious social sciences projects, the level of current developments in the field and formation of a multidisciplinary community, and the funding needs of competing areas such as Environmental, Health and Safety (EHS). The current investment is beginning to create a community with critical mass for advancing research and understanding of the ethical, legal and social issues associated with nanotechnology.

Now, leaving the issue of engineered intelligence, I have some general questions about the NNI which are frankly less important to me than the previous questions, but I hope you will answer them at your convenience.

4. Is your agency involved in a systematic assessment of emerging products of nanoscale science and engineering so that you can identify possible new sources of risk at the earliest possible stage?

Reply: NSF co-organized a grand challenge workshop on the environment, supports four centers for partial support of this topic, and initiated the industry-government working groups on EHS in 2003. NSF does not directly evaluate products, as that is a role that is more pertinent to other agencies and industry.

5. Is your agency involving researchers in the process of identifying and prioritizing research problems, to ensure that research agendas are responsive to stakeholder concerns? What societal research are you supporting to help identify the various ways that nanotechnology risk is being framed by researchers? If you are not engaged in such work, why are you confident that the research you are funding will be valuable for stakeholders?

Reply: NSF provides opportunities for stakeholder input through its process of establishing priorities, including workshops with various communities, joint working groups, direct interactions, grantees meetings, and interagency exchanges. For example, NSF supports projects on safety in manufacturing, occupational health issues, implications for food and agriculture, as well as for long term societal implications.

NSF is supporting research on different approaches to risk assessment and risk perception for nanotechnology. For example, the University of Wisconsin is studying the effect of nanotechnology on food production and risk perception. NSF is funding research and education activities to assess risk for the current and future generations of nanoproducts. All projects are subject to peer review where stakeholders are invited to participate.

6. According to a Congressional Research Services document, the Administration's FY 2007 request for the National Nanotechnology Initiative is a 4% decline in real dollars than what was enacted in FY 2006. Why would we decrease the funding, given the importance of the research?

Reply: The Request for NNI investment has increased each year including in FY 2007 ($1,278 million) as compared to the FY 2006 Request ($1,054 million).